1997

Exchange Rate Regimes and International Trade

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CHAPTER 5

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5.1 Introduction

Empirical applications of the theory of exchange rate regime choice and optimal currency areas typically have involved estimating the effects of exchange rate risk on international trade flows. A finding that a measure of greater exchange rate risk or variability dampens the volume of international trade is interpreted as evidence against the desirability of adopting a floating rate regime (Cushman 1983, 1986; Akhtar and Hilton 1984; Kenen and Rodrik 1986). In actuality, it has proven difficult to establish empirically an unambiguous relation between exchange rate risk measures and trade flows, or a clear correspondence between a country's exchange rate regime and the level of risk.

There are several reasons why research has failed to establish clear relations among risk, exchange rate regimes, and trade flows. First, the relation between exchange rate variability and risk exposure under different exchange rate regimes is tenuous. If, for example, exchange rate fluctuations work to stabilize output in a country subject to aggregate demand shocks, a firm's overall uncertainty about macroeconomic shocks may decrease rather than increase with increased exchange rate variability. Thus, greater exchange rate variability does not necessarily imply greater exposure to risk. Second, the time variation in the subjective evaluation of risk is hard to capture with empirical proxies. This difficulty is particularly acute under pegged exchange rates when exchange rates change infrequently, but uncertainty exists about continued maintenance of the peg.

To overcome these difficulties, in this essay we analyze the empirical relation across countries between exchange rate risk, exchange rate regimes, and international trade, using a measure we call "exchange rate flexibility" to characterize each country's exchange rate regime. Rather than reflect only exchange rate volatility per se, this exchange rate flexibility-measure scales actual exchange rate variability by the total pressure put by macroeconomic shocks on the exchange rate. Thus, it reflects the share of exchange market pressure that is not offset by (unsterilized) intervention, but is allowed to be transmitted into actual exchange rate changes. This measure better captures the risk characteristics associated with a country's exchange rate regime.[1]

We utilize this measure in estimates of price and income elasticities of export and import volumes *across* countries and exchange rate regimes. We argue that there is less ambiguity about the relation between exchange rate risk and trade *elasticities* than about the relation between exchange rate risk and trade volume *levels*. The cross-country approach obviates the need to construct time-dependent country-specific measures of risk and regime that have been shown as difficult to capture by empirical proxies. Moreover, since we expect more variation in both risk and regime across countries than across time for any individual country, the cross-country approach potentially provides greater power in empirical tests.

The plan of the essay is as follows. Section 5.2 discusses the relation between exchange rate risk, exchange rate regimes, and trade volume elasticities. It also motivates the specification of our empirical tests. Section 5.3 describes our data and our estimation procedure involving pooled cross-section times-series equations for U.S. bilateral export and import volumes vis-à-vis its thirty largest trading partners over the period 1980 to 1993. In these pooled regressions we utilize a measure of bilateral exchange rate flexibility for each country relative to the United States over the period. Section 5.4 presents the results, including tests of whether cross-country variations in income and price elasticities depend on cross-country differences in the degree of exchange rate flexibility. In Section 5.5 we discuss how factors other than exchange rate regime-related risk may influence the relation between exchange rate regimes and trade volume elasticities. Conclusions follow in Section 5.6.

5.2 Exchange rate regime, risk, and trade flows

5.2.1 *Empirical literature*

The literature on the relation between exchange rate volatility and international trade typically argues that exchange rate volatility imposes costs on risk-averse firms who generally respond by favoring domestic over foreign trade at the margin. Hooper and Kohlhagen (1978), for example, formulate a model of exporting and importing firms who are risk-averse

to variations in nominal profits, and find it costly to fully hedge exposure to exchange rate risk. In this model, an increase in exchange rate volatility increases the risk facing traders and shifts both export supply and import demand curves back, resulting in a decrease in the equilibrium quantity of traded goods.

The hypothesis that exchange rate volatility has a negative influence on international trade flows has been subject to empirical testing in numerous studies.[2] However, these empirical analyses have in general been unable to establish a significantly negative relationship between measured exchange rate volatility and the volume of international trade in time-series regressions. Hooper and Kohlhagen (1978), estimating effects on bilateral U.S. trade flows, rejected the hypothesis that exchange risk discourages the volume of trade. This was supported by an International Monetary Fund survey (1984) of work in the early 1980s. Cushman (1983) estimated 16 bilateral trade equations and found evidence that exchange risk had a significantly negative effect on trade in six cases and a significantly positive effect in two cases. In a later study (1986), he analyzed the effect of exchange rate risk for U.S. bilateral exports to its six major trading partners, while controlling for risk associated with third-country currencies. Across various specifications and sample periods, less than half of the coefficients on exchange rate risk were ever significantly negative. The evidence from gravity models of bilateral trade flows is more mixed. Thursby and Thursby (1987) find some support for the hypothesis that exchange rate flexibility discourages the volume of trade; however, Brada and Mendez (1988) reject the hypothesis.

Some have argued that by focusing on multilateral rather than bilateral trade flows, misspecification problems arising from not including relative prices involving third country importers and exporters can be avoided. However, studies using multilateral trade flows have provided no more conclusive evidence. Ahktar and Hilton (1984) reported significantly negative effects of exchange rate risk on U.S. and German multilateral exports and German multilateral imports, while Gotur (1985), after updating their work, found a significant negative effect for German imports only, and significantly positive effects on multilateral U.S. exports and Japanese imports. Kenen and Rodrik (1986) analyzed multilateral manufacturing imports for eleven industrial countries and found a significantly negative effect in only four cases.[3] Bailey, Tavlas, and Ulan (1986, 1987) found no significant effect of exchange rate volatility on multilateral exports of industrial countries.

Some have suggested the need to disaggregate trade by goods sectors in order to avoid the aggregation problems that arise when sectors are exposed to exchange risk to different degrees. Maskus (1986), for example, examined real exchange risk effects on U.S. bilateral trade with four countries, disaggregated into nine industry sectors. Of his 64 estimated equations, only 26 had significantly (at a 10 percent level) negative coefficients on exchange rate risk. Klein (1990) analyzed the effects of real exchange rate variability on the proportions of U.S. bilateral exports to seven major trading partners, disaggregated into nine goods categories. In contrast to the results of Maskus, he found that in five of nine categories the volatility of the real exchange rate significantly and positively affected the value of exports; this effect was significantly negative only in one category.

Others have argued that the empirical trade effects of exchange rate risk are sensitive to the statistical techniques employed and have suggested alternative methodologies. However, these results are nonrobust as well. For example, Koray and Lastrapes (1989) and Lastrapes and Koray (1990) estimate vector autoregressions of trade levels and their determinants; they find little or no effect of exchange rate volatility on trade. Utilization of time series techniques that take into account that international trade and its determinants may be nonstationary integrated variables has not provided unambiguous results either. For example, Asseery and Peel (1991) and Arize (1995) estimate error correction models with co-integrating long-run relationships between trade, output, and relative prices. In the former paper, exchange rate risk was found to have a positive effect on exports, whereas in the latter the effect was found to be negative. Gagnon (1993) parameterizes a theoretical model of trade under uncertainty and demonstrates that exchange rate variability of the magnitude typical among industrial countries during the floating rate period has an insignificant effect on the level of international trade.

Our brief review of the empirical literature indicates that time-series analyses have not been successful in establishing a robust relation between exchange rate risk and international trade. As noted in Section 5.1, there are several reasons for the lack of an unambiguous relationship between the exchange rate regime, exchange rate risk, and trade. First, an increase in (nominal or real) exchange rate risk need not be associated necessarily with an increase in uncertainty about macroeconomic conditions. For example, an increase in exchange rate variability associated with the shift to a more flexible exchange rate regime may be accompanied by a reduction in other kinds of risk in the form of lower inflation, interest rate, or output variability. Conversely, although exchange rate variability may be low under a fixed exchange rate regime, uncertainty about inflation, interest rates, or aggregate demand may be

relatively higher instead. Thus, overall uncertainty about macroeconomic conditions is reflected in different variables under different regimes, and is not necessarily correlated with (unconditional or conditional) exchange rate variability.[4] The problem of properly measuring exchange rate regime-related risk is compounded by difficulties in constructing a time-series measure of exchange rate risk, since expectations are inherently difficult to measure.

We seek to overcome these difficulties by analyzing cross-country variations in trade flow responsiveness under different exchange rate regimes, and by utilizing a continuous measure of the degree of bilateral exchange rate "flexibility" over long time periods for individual countries, rather than focusing on exchange rate variability alone. With this flexibility measure, we hope to obtain an improved proxy for the exchange rate regime-related risk faced by firms in international trade. Another difference between our approach and the surveyed literature is that we investigate how trade flow elasticities, rather than trade flow levels, are affected by the exchange rate regime.

5.2.2 *Empirical specification and hypotheses*

To motivate our empirical specification and hypotheses tests, consider the following basic equations from a partial equilibrium model for real U.S. exports (X) to, and U.S. imports (M) from, country j in period t (lagged variables are omitted for simplicity):

$$X_{jt} = x_{cj} + x_{pj}P_{jt} + x_{yj}Y_{jt} + \varepsilon_{xjt} \tag{5.1a}$$

$$M_{jt} = m_{cj} + m_{pj}P_{jt} + m_{yj}Y_{USt} + \varepsilon_{mjt} \tag{5.1b}$$

where P_j denotes the relative price of traded goods between the United States and country j, and is synonymously referred to as the real exchange rate (with a rise in P corresponding to real appreciation of currency j against the dollar); Y denotes real GDP in the importing country; ε_{xjt}, ε_{mjt} are error terms; and x_{ij} and m_{ij}, $i = c, y, p$, are coefficients. All variables are in log form, implying that the coefficients can be interpreted as elasticities. The coefficients are subscripted by country j as well as by time t because exchange risk and other regime characteristics are assumed to vary across countries.[5] In order to focus on the determinants of elasticities, we abstract here from third-country relative prices and nonprice factors, which may also affect trade flow volumes.[6] We focus on the cross-country determinants of the x_{ij} and m_{ij} coefficients, and do not include a time-varying measure of exchange risk, for reasons discussed above. It is assumed that each of these coefficients can be decomposed into a component that is common across countries and a country-specific component that depends on the risk regime and other characteristics of country j, captured by a vector Z_j:[7]

$$x_{ij} = x_{io} + x_{izj}Z_j, \qquad i = c, p, y \tag{5.2a}$$

$$m_{ij} = m_{io} + m_{izj}Z_j, \qquad i = c, p, y \tag{5.2b}$$

The x_{io}, m_{io}-coefficients, for $i = p, y$, reflect the "usual" trade elasticities for relative price and income changes. For each country j, it is hypothesized that an increase in the real price of the country's currency increases U.S. bilateral exports to the country ($x_{po} > 0$) and decreases U.S. bilateral imports from the country ($m_{po} < 0$), while an increase in the importing country's income increases its bilateral imports (x_{yo}, $m_{yo} > 0$).

The coefficients x_{iz}, m_{iz}, $i = c, p, y$, reflect the effects of country-specific risk and other exchange rate regime-related characteristics. (Where possible, we suppress reference to the "j" subscript from now on.) The typical presumption that the *level* of trade flows decreases with the degree of exchange rate risk because of, for example, greater transaction or other costs, implies that the intercept terms depend negatively on Z, that is, x_{cz}, $m_{cz} < 0$.[8] However, as is well-known, uncertainty about influences on product demand and supply may have a positive impact on a firm's desired capital stock and, therefore, on supply: Because profits tend to be multiplicative in factors shifting demand and supply functions, the expected value of future profits can depend positively on the variance of these factors.[9] For this reason the effect of uncertainty about exchange rates and other factors influencing export supply and import demand is ambiguous on theoretical grounds.

In our analysis, we emphasize the cross-country effects of exchange rate regime-related risk on price and income elasticities as well: that is, x_{pz}, m_{pz}, x_{yz}, $m_{yz} \neq 0$. Supply elasticities with respect to price, P, and income, Y, should be relatively sensitive to country characteristics associated with risk and exchange rate regimes because supply decisions generally require investments in capital and other resources necessary for expanding capacity, adapting products to foreign markets, and developing marketing and distribution networks, particularly for manufactures. Because these investment costs are usually irreversible, risk considerations about future prices are particularly important in supply decisions. Since demand decisions occur without any significant commitment of resources over time, risk considerations are of lesser importance for demand responses.

This discussion implies that the variation in the x_{iz}, m_{iz}, $i = p, y$, elasticities across countries is attributable primarily to variations in exporters' supply elasticities. In other words, in the U.S. export equation (5.2a) the cross-country variation in the Z_j-dependent part of the x_p, x_y-coefficients can be associated primarily with the variation in U.S. exporters' supply responses to changes in P_j and Y_j across destination countries with different exchange rate regimes. In the U.S. import equation (5.2b), the variation in the m_{pz}, m_{yz}-coefficients can be associated largely with the variation across countries in foreign exporters' supply responses to changes in P_j and Y_{US}.

Specific hypotheses about the signs of the x_{iz}, m_{iz}, $i = p, y$, coefficients in (5.2a) and (5.2b) require further discussion of the relation between export supply elasticities with respect to P and Y and risk under different exchange rate regimes. Because product supply decisions generally require capital investments, this relation can be better understood by considering how risk affects the elasticity of the desired export-geared capital stock with respect to changes in expected return. Assume, for example, that changes in P_j and Y_j affect the expected relative return (R_j) on the capital stock K_j held by U.S. firms that is geared to exports to country j, and that the riskiness of this return can be attributed to country-specific factors Z_j.

The irreversibility of investment provides one argument why the return elasticity of investment $(dK_j/dR_j)(R_j/K_j)$ and hence the price elasticity of export supply declines with greater uncertainty about the returns to exporting. If investment is irreversible, there is an "option" value of waiting that renders firms cautious about exiting and giving up on investments in foreign markets or investing in entering new markets. With greater uncertainty about the exchange rate and other determinants of investment and supply, the option value of not acting increases. The increased reluctance of firms to deviate from the status quo implies in the aggregate a decline in the elasticity of the capital stock and export supply with respect to the real exchange rate (P_j) and the importing country's GDP (Y_j).[10]

A second argument for reduced elasticities is obtained if one interprets the determination of the capital stock K_j as a portfolio decision. The determination of the desired level of K_j and hence exports to country j then can be interpreted as similar to a portfolio decision by U.S. investors about how many shares of capital, K_j, to hold.[11] Clearly, if risk related to exchange rate regimes were irrelevant for U.S. investors, then the capital associated with exporting to different markets would be perfect substitutes and the desired K_j would be infinitely elastic with respect to R_j; that is, $(dK_j/dR_j)(R_j/K_j)$ would tend toward infinity. If the capital stocks associated with exporting to different markets are not perfect substitutes, then the higher the country-specific risk associated with country j, the less substitutable is K_j for capital geared to exports to other countries, and $(dK_j/dR_j)(R_j/K_j)$ declines.

These arguments imply that, across U.S. exports to countries with different risk and exchange rate regimes, the export elasticity coefficients in (5.2a) will *decrease* as country-related risk, Z_j, increases; that is, $x_{iz} < 0$, $i = p, y$. Analogous arguments can be made for U.S. imports. Therefore, we expect the export supply response to *decrease* (in absolute value) as country-related risk, Z_j, rises; that is, $|m_{pz}| < 0$ and $m_{yz} < 0$.

Beyond risk considerations, other differences across countries, such as in wage–price rigidities, market structure, and so forth, might also affect foreign exporters' supply responses. Only with the assumption that these factors are independent of exchange rate regime and risk can we unambiguously hypothesize that the elasticities m_{pz}, m_{yz} are decreasing in exchange rate regime-related risk. This is our working hypothesis, but, to the extent that price and wage rigidities vary across countries, U.S. bilateral imports provide a less clear test of the relation between elasticities and exchange rate regime-related risk. For this reason, U.S. bilateral exports rather than imports are more likely to reflect variations in elasticities associated with regime-related risk. We return to this issue in Section 5.5.

The relation between risk and exchange rate regimes remains to be discussed. In the empirical analysis we employ two measures of cross-country risk: a traditional measure of exchange rate variability calculated from the variance of exchange rate changes, and an alternative, exchange rate "flexibility" measure. The option value of waiting and portfolio substitutability arguments suggest that a ceteris paribus increase in exchange rate variability that raises risk should decrease the sensitivity of international trade flows to changes in relative prices and income. However, as suggested in Section 5.2.1, from an overall macroeconomic perspective, greater exchange rate variability may imply less, rather than more, risk for firms in international trade. If, for example, exchange rate fluctuations work as an automatic stabilizer of aggregate real demand shocks, overall uncertainty about macroeconomic shocks may decline. Conversely, with lower exchange rate variability the overall risk facing firms in international trade may rise as it shows up more in fluctuations in variables other than the exchange rate. Consequently, overall risk could decline with our exchange rate flexibility measure.

We conclude this section with the specification of our estimating equations and statement of hypotheses based on the discussion above. Substituting (5.2a) and (5.2b) into (5.1a) and (5.1b), respectively, gives the following U.S. bilateral export and import equations:

$$X_{jt} = x_{co} + x_{czj}Z_j + x_{po}P_{jt} + x_{pzj}P_{jt}Z_j + x_{yo}Y_{jt} + x_{yzj}Y_{jt}Z_j + \varepsilon_{xjt} \tag{5.3a}$$

$$M_{jt} = m_{co} + m_{czj}Z_j + m_{po}P_{jt} + m_{pzj}P_{jt}Z_j + m_{yo}Y_{USt} + m_{yzj}Y_{USt}Z_j + \varepsilon_{mjt} \tag{5.3b}$$

In our empirical analysis we also consider other variables, but our interest is focused on the coefficients in (5.3a) and (5.3b). Recalling that P_j denotes the real dollar price of currency j, Y_j denotes income, and Z_j refers to country j's exchange rate risk, exchange rate regime, and other country characteristics, the hypotheses are:

Hypothesis 1. $x_{po} > 0$ and $m_{po} < 0$; i.e., U.S. exports to (imports from) country j increase (decrease) when the currency j appreciates in real terms, relative to the dollar.

Hypothesis 2. $x_{yo} > 0$ and $m_{yo} > 0$; i.e., U.S. exports (imports) increase with an increase in income in country j (United States).

If exchange rate variability is positively associated with risk facing exporters, for Z denoting exchange rate variability, we test the following hypotheses:

Hypothesis 3a. $x_{pz} < 0$ and $x_{yz} < 0$; i.e., the higher the exchange rate variability facing U.S. exporters, the *lower* is the U.S. export elasticity with respect to both the real exchange rate and foreign income.

Hypothesis 4a. $|m_{pz}| < 0$ and $m_{yz} < 0$; i.e., the higher the exchange rate variability facing foreign exporters, the *lower* is the U.S. import elasticity (in absolute value) with respect to both the real exchange rate and U.S. income.

Because of the suggested inverse relation between exchange rate flexibility and the overall risk facing exporters, for Z representing the degree of exchange rate flexibility, we test the following hypotheses:

Hypothesis 3b. $x_{pz} > 0$ and $x_{yz} > 0$; i.e., the greater the degree of exchange rate flexibility facing U.S. exporters, the *higher* is the U.S. export elasticity with respect to the real exchange rate and foreign income.

Hypothesis 4b. $|m_{pz}| > 0$ and $m_{yz} > 0$; i.e., the greater the degree of exchange rate flexibility facing foreign exporters, the *higher* is the U.S. import elasticity (in absolute value) with respect to the real exchange rate and U.S. income.

We do not specify a hypothesis with respect to the effects of risk and regime on the trade volume levels (x_{cz} and m_{cz}). In our empirical analysis, by defining each variable X_j, M_j, P_j, and Y_j for country j as deviations from its mean for that country, we remove country-specific influences, including the effects of risk, on the average level of trade during the estimation period. (This is equivalent to including country-specific intercept dummies.) Because our measures of exchange rate risk vary only across countries and not across time, this precludes testing hypotheses about x_{cz} and m_{cz}. As noted above, however, we do not have unambiguous hypotheses for these coefficients.

5.3 Data and estimation procedure

Our empirical work focuses on quarterly U.S. bilateral trade flows from 1980 through 1993. We restrict our analysis to manufactures trade flows to strip away the effects of trade in agricultural goods and raw materials. Trade in agricultural goods, for example, has typically been more subject to restrictive import quotas or government procurement arrangements than other commodities.

Table 5.1 lists the 30 largest trading partners of the United States that constitute our sample. They are reported in descending order by their share of the summed dollar value of U.S. manufacturing exports, averaged over the period 1990–2. The table also reports their shares of U.S. manufacturing imports. These countries constitute roughly 83 percent of total U.S. manufacturing exports and 80 percent of U.S. manufacturing imports.[12]

The dependent variables of our analysis are the real volumes of manufacturing exports and imports. The real volume of U.S. bilateral exports (X) is defined as the dollar value of bilateral exports deflated by a bilateral export deflator constructed as the weighted dollar price of U.S. exports of capital goods, airplanes, and other durable manufactures, with time-varying quarterly weights given by the foreign country's share of each category in its total manufacturing imports from the United States. The real volume of U.S. bilateral imports (M) is defined as the dollar value of bilateral imports deflated by the product of the foreign wholesale price and the dollar price of foreign exchange. A detailed description of the sources and construction of data is contained in the Appendix.

Among our explanatory variables, the relative price variable P (i.e., the real exchange rate) used in both the export and import bilateral trade equations is defined as the nominal spot rate (quoted as dollars per foreign currency of country j) times the ratio of country j's wholesale price index to the U.S. wholesale price index. Y is the real income in the importing country, defined as nominal GDP deflated by the implicit GDP deflator; Y_{US} is U.S. real GDP. Limitations on the

Table 5.1. *U.S. bilateral manufactured trade, share of total manufacturing trade (percent)*

	Country	Exports	Imports
1	Canada	27.36	18.40
2	Japan	10.74	31.64
3	Mexico	9.73	7.70
4	United Kingdom	7.40	4.58
5	Germany	6.84	7.91
6	France	4.87	3.45
7	Netherlands	3.26	0.84
8	Korea	3.23	5.68
9	Singapore	2.93	3.55
10	Australia	2.73	0.29
11	Belgium	2.53	0.60
12	Italy	2.32	3.19
13	Brazil	1.69	1.26
14	Switzerland	1.57	1.38
15	Malaysia	1.52	2.17
16	Spain	1.39	0.57
17	Venezuela	1.31	0.06
18	Sweden	1.15	1.38
19	Thailand	1.08	1.67
20	Ireland	0.95	0.48
21	Israel	0.82	0.62
22	Philippines	0.69	1.15
23	Argentina	0.66	0.09
24	Colombia	0.66	0.14
25	Chile	0.62	0.04
26	Indonesia	0.52	0.63
27	Norway	0.47	0.11
28	Denmark	0.45	0.32
29	New Zealand	0.32	0.04
30	Greece	0.22	0.05

Note: Calculations are averages for 1990–2.

availability of some variables restricted the data range for some countries.[13]

We have also constructed measures of cross-country characteristics (represented by the variable Z in our notation above) that may potentially influence the volume and elasticities of trade. These included two exchange rate risk measures – the variance of bilateral exchange rate changes ($XRVAR$) and the degree of bilateral exchange rate "flexibility" ($XRFLEX$) – and a measure of each country's openness ($OPEN$). The definition and construction of these variables is defined below. Table 5.2 presents the values of these variables as constructed for the sample period indicated for each country.[14]

The variance of the exchange rate ($XRVAR$) is measured conditionally from the residuals of a regression of percent monthly (log) changes in the nominal exchange rate (expressed as domestic currency per U.S. dollar) on 12 months of lagged changes, together with 11 seasonal dummies. As is usually the case, it makes little quantitative difference whether anticipated or unanticipated, or nominal or real, exchange rates are used instead.[15]

Our measure of exchange rate flexibility, $XRFLEX$, is intended to capture the variance of the actual exchange rate change relative to the variance of the change that would have occurred in the absence of foreign exchange market intervention. $XRFLEX$ is defined as

$$XRFLEX_j = \frac{XRVAR_j}{XRVAR_j + RESVAR_j} \tag{5.4}$$

where $RESVAR_j$ denotes the variance of changes of foreign exchange reserves in domestic currency terms, measured as a fraction of the lagged monetary base in country j. Analogously to $XRVAR$, $RESVAR$ is constructed from the residuals of the actual monthly change (divided by the lagged base) regressed on 12 lags of the dependent variable, together with seasonals. The denominator in (5.4) can be interpreted as a measure of the variance of the "total" pressure put by macroeconomic shocks on the exchange rate, given by the sum of actual as well as "incipient" exchange rate variability. $RESVAR_j$ captures the "incipient" change in the exchange rate that is prevented from occurring as a result of foreign exchange market intervention by country j. The change in foreign exchange reserves (in domestic currency terms) is scaled by the monetary base because of the assumption that (unsterilized) foreign exchange market intervention amounting to a 1-percent rise (fall) in the monetary base prevents a 1-percent domestic currency appreciation (depreciation).[16] $XRFLEX$ thus measures the proportion of the pressure on the exchange rate caused by macroeconomic shocks that is allowed on average over the period to translate into actual exchange rate changes. The exchange rate is perfectly flexible, that is, $XRFLEX = 1$, if there are no unanticipated reserve changes ($RESVAR = 0$). The exchange rate is perfectly fixed, that is, $XRFLEX = 0$, if there are no unanticipated changes in the exchange rate ($XRVAR = 0$) or if the variance of reserve changes is very large ($RESVAR = \infty$).

Table 5.2. *Cross-country regime characteristics*

Country	Abbreviation	Sample	Range	*XRVAR*	*XRFLEX*	*OPEN*
Canada	can	80:1	93:12	0.15	0.08	0.46
Japan	jap	80:1	93:12	1.00	0.94	0.19
Mexico	mex	80:1	93:12	3.69	0.28	0.21
United Kingdom	gbr	80:1	93:12	1.23	0.53	0.40
Germany	deu	80:9	93:12	1.11	0.51	0.48
France	fra	80:1	93:12	1.12	0.48	0.36
Netherlands	nld	80:1	93:12	1.14	0.37	0.95
Korea	kor	80:1	93:12	0.21	0.08	0.58
Singapore	sin	80:1	93:12	0.16	0.04	2.97
Australia	aus	80:1	93:12	0.84	0.27	0.27
Belgium	blx	80:1	92:12	1.17	0.33	1.23
Italy	ita	80:1	93:9	1.01	0.78	0.34
Brazil	bra	80:1	92:12	3.31	0.30	0.16
Switzerland	che	80:1	93:3	1.32	0.60	0.57
Malaysia	mal	80:1	93:12	0.15	0.02	1.05
Spain	esp	80:1	93:12	1.10	0.68	0.28
Venezuela	ven	80:1	93:12	9.13	0.46	0.42
Sweden	swe	80:1	93:12	1.02	0.12	0.29
Thailand	tha	80:1	92:12	0.24	0.10	0.49
Ireland	irl	80:1	93:12	1.08	0.10	0.98
Israel	isr	80:1	93:9	1.10	0.47	0.56
Philippines	phi	80:1	93:12	0.98	0.17	0.40
Argentina	arg	80:1	90:12	41.52	0.79	0.12
Colombia	col	80:1	93.9	0.01	0.00	0.25
Chile	chi	80:1	93:12	0.88	0.52	0.42
Indonesia	idn	80:1	93:12	1.35	0.26	0.39
Norway	nor	80:1	93:12	0.87	0.04	0.56
Denmark	dnk	80:1	93:12	1.06	0.04	0.53
New Zealand	nzl	80:1	93:12	1.12	0.01	0.43
Greece	grc	80:1	91:3	1.01	0.56	0.37

Note: $XRVAR$, $XRFLEX$, and $OPEN$ denote the variance of exchange rate changes, the degree of exchange rate flexibility, and multilateral openness, respectively, calculated over the sample range indicated. See the Data Appendix for details of calculation. $XRVAR$ figures are multiplied by 1,000.

Figure 5.1 shows a scatter plot of the log of the exchange rate variance against the degree of exchange rate flexibility for each country calculated over the sample period (the abbreviations used for individual countries are presented in Table 5.2). The variances are logged to reduce the extreme spread of the unlogged values. Observe that there is very little cross-country variation in the amount of exchange rate volatility against the dollar. This can be attributed largely to the fact that almost half of the countries in the sample, particularly those participating in the European

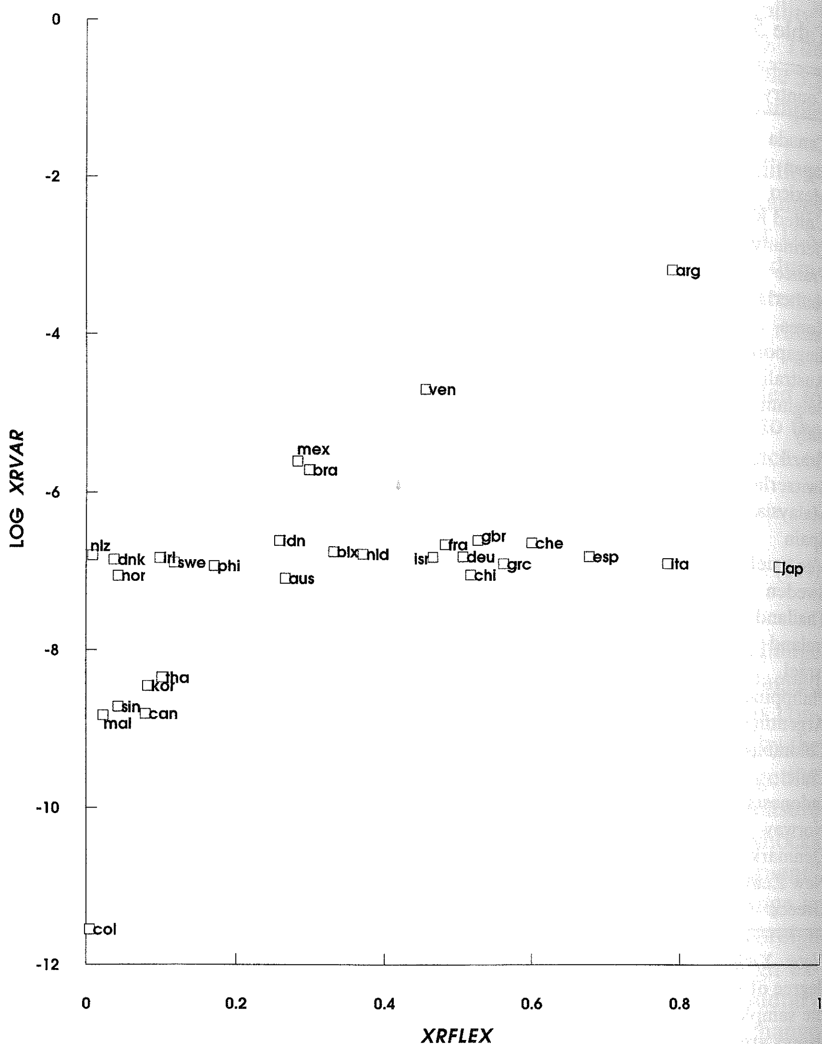

Figure 5.1. Variance of the exchange rate (*XRVAR*) and the degree of exchange rate flexibility (*XRFLEX*).

Exchange Rate Mechanism, limit exchange rate changes against each other much more than against the dollar. The lack of variation in *XRVAR* limits its usefulness in cross-country estimation because of multicollinearity problems it introduces between this variable and the magnitude of real exchange rate changes across countries. In contrast,

XRFLEX is distributed over its full range, reflecting cross-country variations in intervention policy.[17]

The lack of cross-country variation in *XRVAR* implies, from inspection of the definition of *XRFLEX* (equation (5.4)), that the cross-country variation in *XRFLEX* is dominated by variation in *RESVAR*, capturing differences in individual countries' average inclination to intervene against pressures on the exchange rate. In other words, because there is little variation across countries in *XRVAR*, *XRFLEX* decreases the more that foreign exchange market pressures are absorbed by changes in foreign exchange reserves. Thus, to the extent that the total risk faced by exporting firms rises with foreign exchange market pressure from macroeconomic shocks, an increase in exchange rate flexibility, *XRFLEX*, may be interpreted as a *fall* in total risk. This is in accordance with our Hypotheses (3b) and (4b).

A measure of each country's multilateral openness to international trade over the sample period, *OPEN*, is also reported in Table 5.2. *OPEN* is defined as the sum of a country's total (nominal) exports and imports relative to (nominal) GDP. This variable is intended to capture factors influencing trade flows, such as the degree of foreign competition in a country's markets, as well as to control for non-risk-related country characteristics that might affect trade flows and trade flow elasticities.

Our specification follows equations (5.3a) and (5.3b), augmented with seven lags of the real exchange rate P; income Y enters only contemporaneously. Interactive terms involving the degree of exchange rate flexibility (*XRFLEX*) and openness (*OPEN*) are included with the same number of lags as the associated variable. Seasonal dummies and a time trend are included as well. The time trend is intended to capture possible exogenous worldwide growth in trade volumes. In one set of regressions, exporting countries' GDP is included as well in order to control for other supply effects and check the robustness of results.

The regressions for U.S. bilateral exports and imports were estimated using a pooled times-series cross-section analysis with fixed effects. This procedure produces more efficient coefficient estimates than a two-stage procedure to explain the cross-country variation in the elasticity coefficients for relative prices and income. To control for country-specific autocorrelation and cross-country heteroscedasticity we used the following estimation procedure: (i) for each individual country, an estimate of the first-order serial-correlation coefficient (ρ_j) was obtained from the residuals of an OLS log-linear regression of exports (or imports) on 0 to 7 lags of P, contemporaneous Y or Y_{US}, and seasonal dummies[18]; (ii) quasi-differencing the data for each country with ρ_j, that is, forming $X_{jt} - \rho_j X_{jt-1}$ for the dependent and explanatory variables, in order to control for serial correlation later in the pooled regression; (iii) repeating OLS for each country on its quasi-differenced data, obtaining the standard error equation estimate (SEE_j), and then scaling the quasi-differenced data for each country by this value, SEE_j, to control for heteroscedasticity across country equations; (iv) then taking the deviation from the mean of each transformed data series for the period, in order to control for fixed country effects; (v) for each variable, stacking all of the individual country data into pooled time-series vectors; and (vi) with these pooled vectors, obtaining OLS estimates of the regression specification described above. This procedure provides a consistent estimate of coefficients (see Kmenta 1986).[19] The sample range of observations for individual countries in the stacked dependent-variable vectors is indicated in Table 5.2; the explanatory variable vectors are augmented by the appropriate number of lags.

Note that the transformation of data into deviations from the mean is equivalent to including country intercept dummies in the pooled regressions.[20] In this way we control for differences in trade flow levels across countries due to such time-invariant factors as distance from the United States.

5.4 Empirical results

Tables 5.3 and 5.4 report the results of our pooled regressions. The coefficient estimates for the real exchange rate, the importing country's GNP, the interactive term (*P·XRFLEX*), and the time trend are given in column (1). In column (2), a second interactive term (*Y·XRFLEX*) is added. In column (3) the openness variable, *OPEN*, is added interactively with both of the time-varying variables. Column (4) augments this regression with the contemporaneous (transformed) level of exporting countries' GDP. The coefficient reported for the real exchange rate when entered alone and interactively is the sum of the coefficients for lags 0 through 7. We report results for all 30 countries in the sample, and for the 17 OECD countries alone in columns (5)–(8).[21] Results for OECD countries alone are included because the OECD countries can be expected to be more homogeneous with respect to various factors influencing trade flows that are not captured in the regressions. The reported standard errors are based on White's (1980) heteroscedasticity-consistent covariance matrix.[22] Plots of the residuals of the export and import regressions indicate that the residuals are of similar magnitudes across countries, with only a few outliers.[23]

Table 5.3 shows that the export volume elasticities with respect to the real exchange rate and foreign GDP have the expected positive sign and

Table 5.3. Pooled bilateral U.S. manufactures exports

Explanatory variables	All countries (1)	(2)	(3)	(4)	OECD countries (5)	(6)	(7)	(8)
P	0.61 (0.10)***	0.66 (0.10)***	0.70 (0.13)***	0.36 (0.12)***	0.84 (0.13)***	0.98 (0.14)***	1.18 (0.23)***	1.10 (0.21)***
Y	1.45 (0.07)***	1.38 (0.07)***	1.28 (0.09)***	1.15 (0.09)***	1.83 (0.16)***	1.56 (0.21)***	1.25 (0.27)***	0.30 (0.23)
$P \cdot XRFLEX$	0.79 (0.19)***	0.52 (0.20)**	0.44 (0.22)**	1.10 (0.21)***	0.30 (0.22)	−0.05 (0.25)	−0.18 (0.27)	−0.02 (0.25)
$Y \cdot XRFLEX$		0.69 (0.18)***	0.82 (0.20)***	0.35 (0.19)*		0.70 (0.29)**	0.91 (0.31)***	1.09 (0.25)***
$P \cdot OPEN$			0.02 (0.11)	0.14 (0.10)			−0.30 (0.27)	−0.35 (0.24)
$Y \cdot OPEN$			0.09 (0.05)*	0.09 (0.04)*			0.77 (0.41)*	0.91 (0.30)***
$TREND$	0.03 (0.00)***	0.03 (0.00)***	0.03 (0.00)***	−0.00 (0.01)	0.03 (0.01)***	0.03 (0.01)***	0.02 (0.01)***	−0.02 (0.01)**
Y_{US}				1.34 (0.17)***				2.00 (0.21)***
$\bar{R}^2$	0.71	0.71	0.72	0.75	0.74	0.74	0.74	0.79
$D. W.$	1.75	1.78	1.78	1.56	1.84	1.84	1.84	1.73
SEE	1.23	1.23	1.23	1.29	1.22	1.22	1.22	1.22

Notes: The dependent variable is (logged) real bilateral manufactured exports *X*. *P*, *Y*, and Y_{US} denote the (logged) real dollar price of foreign exchange, foreign GDP, and U.S. GDP, respectively. *XRFLEX* and *OPEN* denote the degree of exchange rate flexibility and multilateral openness, respectively. Details of the estimation procedure are described in the text. Heteroscedastic-adjusted standard errors in parentheses; * denotes significance at the 0.10 level; ** denotes significance at the 0.05 level; *** denotes significance at the 0.01 level.

Table 5.4. *Pooled bilateral U.S. manufactures imports*

Explanatory variables	All countries (1)	(2)	(3)	(4)	OECD countries (5)	(6)	(7)	(8)
P	−1.14	−1.23	−1.33	−1.82	−0.92	−1.01	−1.41	−1.48
	(0.11)***	(0.12)***	(0.17)***	(0.13)***	(0.13)***	(0.15)***	(0.26)***	(0.20)***
Y_{US}	2.53	2.92	2.69	3.80	2.77	3.05	2.60	2.13
	(0.12)***	(0.19)***	(0.24)***	(0.26)***	(0.15)***	(0.23)***	(0.33)***	(0.30)***
$P \cdot XRFLEX$	−0.25	0.00	0.03	0.50	−0.45	−0.26	−0.01	0.08
	(0.19)	(0.21)	(0.23)	(0.20)**	(0.21)**	(0.26)	(0.30)	(0.25)
$Y_{US} \cdot XRFLEX$		−0.83	−0.67	−2.23		−0.53	−0.27	−0.61
		(0.28)***	(0.31)**	(0.30)***		(0.32)*	(0.34)	(0.30)**
$P \cdot OPEN$			0.22	0.17			0.70	0.42
			(0.17)	(0.12)			(0.31)**	(0.19)**
$Y_{US} \cdot OPEN$			0.39	−0.36			1.23	1.35
			(0.18)**	(0.16)**			(0.45)***	(0.30)***
$TREND$	0.04	0.04	0.04	0.01	0.01	0.01	0.00	−0.00
	(0.00)***	(0.00)***	(0.00)***	(0.01)**	(0.01)*	(0.01)	(0.01)	(0.01)
Y				1.00				0.75
				(0.15)***				(0.13)***
$\bar{R}^2$	0.64	0.64	0.64	0.78	0.65	0.65	0.66	0.72
$D. W.$	1.76	1.77	1.77	1.30	1.84	1.84	1.88	1.60
SEE	1.36	1.36	1.36	1.75	1.32	1.32	1.31	1.35

Notes: The dependent variable is (logged) real bilateral manufactured imports M. P, Y_{US}, and Y denote the (logged) real dollar price of foreign exchange, U.S. GDP, and foreign GDP, respectively. *XRFLEX* and *OPEN* denote the degree of exchange rate flexibility and multilateral openness, respectively. Denmark is excluded from all regressions. Details of the estimation procedure are described in the text. Heteroscedastic-adjusted standard errors in parentheses; * denotes significance at the 0.10 level; ** denotes significance at the 0.05 level; *** denotes significance at the 0.01 level.

are strongly significant in all specifications, as is consistent with Hypotheses 1 and 2. For the full sample of countries, both of the interactive terms involving the degree of flexibility (*XRFLEX*) are positive and significant across specifications without and with the openness interaction terms (though including Y_{US} does lower the significance level for the interactive term with foreign GDP). Thus, both the real exchange rate elasticity of U.S. exports as well as the elasticity of U.S. exports with regard to foreign GDP *increase* (in absolute value) as the degree of exchange rate flexibility rises, as Hypotheses (3b) and (4b) imply when greater flexibility is associated with lower risk. For OECD countries alone, the interactive term with the degree of exchange rate flexibility is significant and positive only in its effect on the elasticity with regard to foreign GDP. The finding of a positive effect of exchange rate flexibility on U.S. exports and the interpretation that greater exchange rate flexibility is associated with lower risk is supported by the observation in Section 5.3 that most of the variation in our exchange rate flexibility measure is attributable to differences in incipient exchange rate changes offset by central bank intervention, rather than to differences in exchange rate variability per se.

Regressions with exchange rate variability, *XRVAR*, substituted for exchange rate flexibility, *XRFLEX*, are not presented here, but the main results are easily summarized. Both of the interactive terms, $P \cdot XRVAR$ and $Y \cdot XRVAR$, are far from significant in all specifications. As noted, this insignificance can be attributed to the small variation in exchange rate variability across countries.

To enhance our understanding of the relation between exchange rate flexibility and U.S. export elasticities, Figure 5.2 presents a scatter plot of individual country export elasticities with respect to the real exchange rate (x_{pz}) against our measure of exchange rate flexibility, *XRFLEX*. The price elasticities for each country are estimated from an OLS log-linear regression using the quasi-differenced and *SEE*-scaled data following the general export equation specification. The elasticity and exchange rate flexibility observations for each country are weighted by the standard deviation of its (quasi-differenced and scaled) real exchange rate. This weighting procedure is analogous to the weight given each country's observations in the pooled regressions and gives the more uncertain estimates less weight.[24] The scatter plot shows a positive relation between the export elasticities and the degree of exchange rate flexibility, consistent with the positive sign on the corresponding interaction term in the pooled regression; the positive relation is robust with respect to removal of outliers from the sample of countries.[25]

Table 5.4 reports the results for U.S. bilateral manufacturing imports

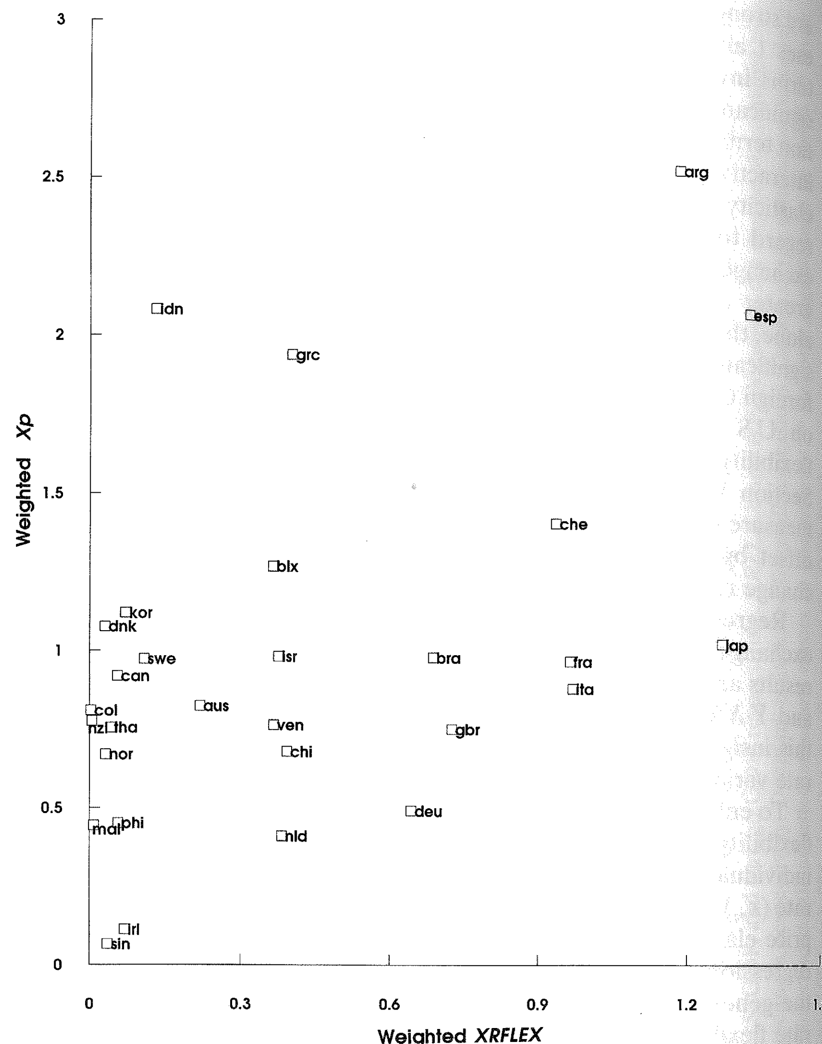

Figure 5.2. OLS estimates of export elasticity against exchange rate flexibility.

from all countries and for OECD countries.[26] Import volume elasticities with respect to the real exchange rate and U.S. GDP have the signs consistent with Hypotheses 1 and 2 (negative and positive, respectively) and are strongly significant in all specifications. In the full sample, the interactive term involving P and $XRFLEX$ is positive and significant

only for the case reported in column (4), where exporters' GDPs are included. The positive sign implies that the absolute value of the real exchange rate elasticity declines, contrary to Hypothesis (4b). The interaction term with Y_{US} is negative and significant (mostly at better than 1 percent), indicating that the elasticity with respect to U.S. GDP *falls* as exchange rate flexibility increases. This is contrary to Hypothesis (4b) as well. The latter effect is robust to the inclusion of interaction terms with the openness variable, as well as exporters' GDPs. For the smaller OECD sample, the two interaction terms involving $XRFLEX$ are both significantly negative when entered individually; but when both are included, only the term with Y_{US} is significant (though only at 10 percent). The negative effect is especially strong when both openness and exporters' GDP are included. Again the results are contrary to Hypothesis (4b).

The import equations were also estimated, with $XRVAR$ substituted for $XRFLEX$. As with the export equations, the interactive term $P{\cdot}XRVAR$ was insignificant in all specifications. However, the term $Y_{US}{\cdot}XRVAR$ was generally positive and significant at the 5 or 10 percent level. The positive sign suggests that the import income elasticity increases with exchange rate variability.

We noted in Section 5.2 that the import equations are less suitable for testing our hypotheses, because foreign exporters' supply responses may depend on other country characteristics not considered here. In particular, the import equation results could be influenced by the cross-country correlation between the exchange rate regime, exchange rate variability, and wage and price rigidities.[27] We return to a discussion of the import equation results in Section 5.5.

Turning finally to the interaction variables involving openness, reported in columns (3), (4), (7), and (8) of Tables 5.3 and 5.4, we find that for both U.S. exports and imports the elasticities with respect to importers' GDP generally increase with foreign country openness (the exception is when foreign GDP is added to the U.S. import equation). In other words, the more open are foreign economies, the greater the response of U.S. exporters to foreign income demand shifts, as well as the response of foreign exporters to U.S. income demand shifts.

The interaction of openness with the real exchange rate is not significant in the case of exports. In the case of U.S. imports, particularly for the OECD sample, there is some indication that the elasticity with respect to the real exchange rate falls (in absolute terms, since the algebraic coefficient for $P{\cdot}OPEN$ is positive) with greater openness abroad. We abstain from speculating about explanations for this result.

We conclude this section by briefly comparing the results presented

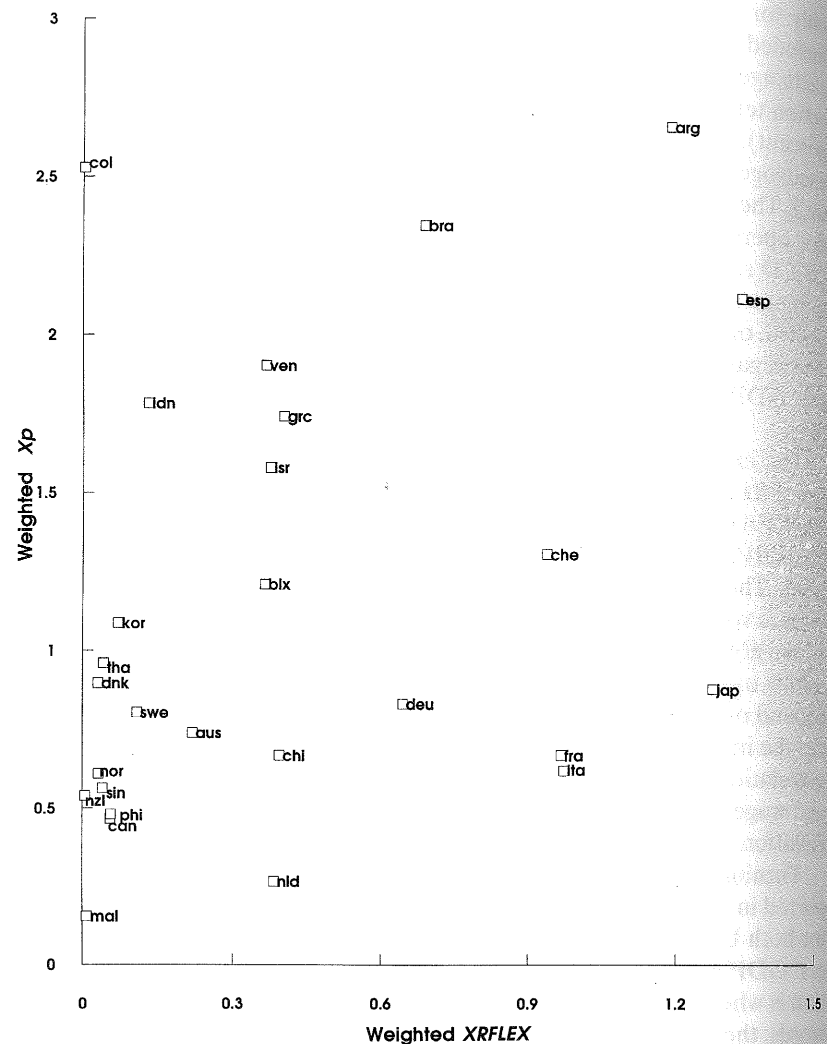

Figure 5.3. Johansen estimates of export elasticity against exchange rate flexibility.

here for pooled cross-section, time-series analysis with results using alternative procedures. In particular, the Johansen procedure for estimating long-run export elasticities in an error-correction model was implemented.[28] The scatter plot in Figure 5.3 reveals that the relation between the (weighted) real exchange rate elasticity for U.S. bilateral

exports and the (weighted) degree of exchange rate elasticity using the Johansen procedure is similar to the relation between the same two variables in Figure 5.2, where individual country elasticities were OLS-estimated.[29] Thus the relation between bilateral export elasticities and our measure of exchange rate flexibility appears robust to estimation procedure.

5.5 Exchange rate regime and elasticities: Additional considerations

Although we found that U.S. bilateral export elasticities *increase* with the degree of bilateral exchange rate flexibility of the importing country, the U.S. bilateral import regression results showed that increasing exchange rate flexibility in the exporting country is associated with a *decreasing* elasticity of country *j* exports (in absolute terms) with respect to changes in U.S. GDP. If higher values of our exchange rate flexibility measure reflected increased risk for exporters, then this result would be in accordance with conventional hypothesis, but we have argued that increasing flexibility is associated with less risk.

In Section 5.2 we suggested that the U.S. import regressions provide a weaker test of the relation between elasticities and exchange rate regime-related risk than do the export regressions. The reason is that the variation in export supply elasticities across countries affecting U.S. import elasticities is most likely to be strongly influenced by country-specific factors abroad, such as factor market and price flexibility. It is possible that the variation in these factors and the endogenous choice of exchange rate regimes play a role in our import results.

To explore this possibility further, we refer to the optimum currency area literature concerning the criteria for exchange rate regime choice.[30] A central tenet of the OCA literature is that exchange rate adjustment may substitute for nominal wage flexibility and/or labor mobility in response to aggregate demand or supply shocks. Thus, the benefits of flexible exchange rates rise with increasing rigidity of wages and labor supply. It follows that if the responsiveness of a foreign country's export supply decreases with a country's degree of labor market rigidity, and if countries choose their exchange rate regime taking into account labor market rigidities, then lower export supply elasticities would tend to be associated with greater exchange rate flexibility. As a result, in a cross-section of U.S. import elasticities with respect to U.S. GDP, the endogeneity of exchange rate regimes with respect to foreign supply elasticities would explain the observation that elasticities decrease (in absolute value) as bilateral exchange rate flexibility increases.

In another strand of the OCA literature, openness plays a major role for the relative benefits and costs of exchange rate regimes. McKinnon (1963) argued that the inflationary (deflationary) impact of a depreciation (appreciation) is larger in an open economy than in a closed economy. The explanation is that a large share of goods in the price index is affected by an exchange rate change immediately or, at least within a short time. If so, the supply response to an exchange rate change will be relatively small, even if the exchange rate change initially is real, because of expectations that the exchange rate change is likely to be reversed in the near future. Under these circumstances, the export supply elasticity with respect to a contemporaneous exchange rate change will be low in a relatively open economy. The positive sign for openness when interacting with the (negative) real exchange rate elasticity in U.S. imports, as reported in Table 5.4, is consistent with this reasoning.

5.6 Conclusions

In this essay we have reexamined the existing evidence on the trade volume effects of exchange rate risk and exchange rate regime choice. Our analysis involved estimating the effects of cross-country differences in exchange rate regime on export and import elasticities using a continuous measure of the degree of exchange rate flexibility. We have argued that risk for firms involved in international trade tends to decrease with greater exchange rate flexibility. In formulating our hypotheses we argued that the cross-country variation in U.S. export elasticities with respect to the real exchange rate and foreign GDPs is primarily attributable to the cross-country variation in bilateral exchange rate regime-related risk. The cross-country variation in U.S. import elasticities, on the other hand, may depend on additional factors influencing supply conditions in exporting countries.

The empirical results showed that U.S. export elasticity *increases* with the degree of bilateral exchange rate flexibility of the importing country. We interpreted this result as an indication that the total macroeconomic risk exporters face decreases with the degree of exchange rate flexibility in accordance with our hypotheses. This interpretation is supported by the observation that increasing exchange rate flexibility across our sample of countries is correlated with decreasing variability in foreign exchange market pressures. Thus, our empirical evidence lends no support to the conventional presumption that firms face more risk under floating exchange rates, and that exchange rate flexibility reduces international trade.

The results for U.S. bilateral imports showed that the elasticity with respect to U.S. GDP *decreases* with higher exchange rate flexibility. The optimum currency area literature provides an explanation for this result under the presumption that countries with substantial labor market rigidities, and therefore low export elasticities, are more likely to choose a high degree of exchange rate flexibility to facilitate price adjustment.

The analysis of this paper can be extended in several directions. One possibility is to take account of industrial composition effects. To the extent that export supply elasticities vary across industries, the effects of cross-country differences in exchange rate regimes and risk on international trade flows may depend on the industrial composition of exports to destination markets. This would involve working with disaggregated manufacturing data and pooling both across countries and across industries, while also adding variables to control for industry-specific characteristics that reflect differential exposure to risk. Another avenue for future research is to take account of how the nature of underlying shocks – for example, domestic or foreign, real or nominal, permanent or temporary – influences adjustment behavior across exchange rate regimes. This would require a more formal analysis of the joint determination of international investment, production, and trade flow decisions in a general equilibrium stochastic framework. Such a framework would yield testable hypotheses about how international trade behavior depends on the underlying sources of exchange rate variability.

DATA APPENDIX

Quarterly data for the period 1978:I to 1993:IV for the dollar value of bilateral manufactured exports and imports were obtained from the Department of Commerce, Bureau of Economic Analysis Trade Database. Manufactured trade flows are defined as the sum of trade in capital goods (except automobiles), automotive vehicles, manufactured consumer nondurable goods, and manufactured consumer durable goods.

The real volume of U.S. bilateral exports (X) is defined as the dollar value of bilateral exports deflated by a bilateral export deflator constructed as the weighted dollar price of U.S. exports of capital goods (except automotive), automotive vehicles, and consumer manufactures, with time-varying quarterly weights given by the foreign country's share of each goods category in its total bilateral manufacturing imports from the U.S. The price data for U.S. manufactured export categories were obtained from the Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*. Since the price index for exports of capital goods (excluding automotive) was unavailable before 1982:I, we backfilled missing observations by assuming that they grew at the same rate as available data on "other" capital goods that excluded airplane and computer equipment.

The real volume of U.S. bilateral imports (M) is defined as the dollar value of bilateral imports deflated by the product of the foreign wholesale price and the (period average) dollar price of domestic currency. The bilateral exchange rate and wholesale price data were obtained from the International Monetary Fund *International Financial Statistics* (lines rh and 63, respectively). Due to the unavailability of quarterly wholesale price numbers for France and Malaysia, the consumer price index (line 64) was used instead for these countries.

The relative price variable (P), that is, the real exchange rate, is defined as the (period average) dollar price of the domestic currency times the domestic wholesale price index divided by the U.S. wholesale price index. (A rise in P corresponds to a real appreciation of the domestic currency against the dollar.)

Real gross domestic product (Y) data were obtained from *IFS* line 99 b.r. Where only annual real gross domestic product numbers were available (Belgium, Brazil, Chile, Colombia, Denmark, Indonesia, Ireland, Malaysia, Mexico, New Zealand, Philippines, Thailand, Venezuela, and Singapore), the annual observations were interpolated to obtain quarterly observations, using a distribution procedure provided by the econometric software package RATS.

The measures of exchange rate variability ($XRVAR$) and flexibility ($XRFLEX$) were constructed for each country from monthly data, also obtained from the *IFS* (the sample periods for these measures are given in Table 5.2). The bilateral exchange rate was measured by the end-of-month domestic currency per dollar rate (line ae). The monetary base ("reserve money") and foreign exchange reserves ("total reserves, excluding gold") were obtained from line 14 and line 11.d, respectively; the latter series was converted into domestic currency units using the end-of-month exchange rate. Since the base series for Colombia had missing values for 1983.1–1982.2, 1983.4–1983.5, 1985.7–1985.8, 1985.11, 1986.1, 1986.7, 1986.10–1986.11, 1987.1–1987.2, 1987.4–1987.5, they were interpolated using the RATS distribution procedure. In addition, in the case of the United Kingdom, a consistent monthly series for the base was not available prior to 1986.9 because of a change in definition (with the Building Societies Act of 1986) that began treating deposits of building societies as part of reserves. We used the average of the ratio of observations from the old definition and the new definition for two overlapping quarters (1986:III and 1986:IV) to scale up quarterly numbers available for the old definition to match the new definition for the period prior to 1986.9. These scaled-up new quarterly numbers were then interpolated to obtain monthly observations using the RATS distribution procedure as above.

The variance of the exchange rate ($XRVAR$) is measured conditionally from the residuals of a regression of percent monthly (log) changes in the (end-of-period) nominal exchange rate on 12 months of lagged changes, together with 11 seasonal dummies. $XRFLEX$ was defined as by equation (5.4) with $RESVAR$ constructed from the residuals of the actual monthly change in reserves (divided by the lagged base) regressed on 12 lags of the dependent variable, together with seasonals.

The openness variable ($OPEN$) was constructed as the sum of a country's total nominal exports and imports in domestic currency (lines 70 and 71.v, respectively) divided by nominal GDP (line 99b.c). Due to the unavailability of multilateral exports and imports in local currency for Argentina, Brazil, Chile, Colombia, Indonesia, and Venezuela, multilateral exports and imports in U.S. dollars (lines 70..d and 71.vd) were converted to local currency using the period average exchange rate (line rf) for these countries.

NOTES

Research assistance by Barbara Rizzi is gratefully acknowledged. We thank Tamim Bayoumi, Benjamin Cohen, Linda Goldberg, and Richard Sweeney for helpful comments. The views presented in this paper are those of the authors alone and do not reflect those of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System.

1. Related measures of exchange rate flexibility have been developed by Holden, Holden, and Suss (1979) to test optimum currency hypotheses, and by Glick, Kretzmer, and Wihlborg (1995) to explain cross-regime differences in the real effects of monetary shocks.
2. Edison and Melvin (1990) provide a critical survey of the empirical literature on exchange rate volatility and international trade.
3. Nevertheless, Kenen and Rodrik interpreted their findings as evidence in support of arguments for greater exchange rate fixity.
4. Oxelheim and Wihlborg (1987) explore the corporate finance implications of this view.
5. The standard partial equilibrium model assumes two countries, each producing a single tradable good that is an imperfect substitute for the good produced in the other country. If, as is often assumed in the empirical estimation of international trade equations, supply elasticities are infinite, then the estimated coefficients depend only on demand elasticities in the importing country. However, below we assume that supply elasticities are less than infinite, but that supply effects show up primarily in the cross-country variation in sensitivity to exchange-rate regime-related risk.
6. In our empirical analysis we report results for regressions augmented by the GDP of the exporting country to control for supply effects not otherwise captured. Hooper and Marquez (1995) survey the large number of empirical studies, using a wide variety of theoretical models and estimation techniques, that have estimated price and income elasticities of international trade.
7. We discuss these country-specific characteristics more fully in the following section.
8. It is generally recognized in the corporate finance field that a project's "own" variance increases the cost of capital even when shareholders can diversify project-specific risk. Another argument for a negative effect of risk on the capital stock involves viewing the firm as having an option as long as investment in sunk costs has not taken place. The value of this option increases with uncertainty.
9. See, for example, Giovannini (1988) and Aizenman (1992). Brada and

Mendez (1988) suggest that a positive relation between exchange rate variability and trade flows may arise because of an association of fixed exchange rates with restrictive commercial policies.

10. See, for example, Dixit (1989a, 1989b) and Baldwin and Krugman (1989); a particularly accessible variation of this argument can be found in Krugman (1989, chap. 2). Aizenman (1992), Goldberg and Kolstad (1995), and Goldberg (this volume) explore the international direct investment implications of variable exchange rates more formally. Aizenman (1992) formulates an open economy model in which risk-neutral producers engage in foreign investment in order to achieve ex post production flexibility and higher profits in response to real and nominal shocks. He characterizes how the association between investment and exchange rate variability depends on the nature of the underlying shocks. Goldberg and Kolstad (1995) show how investment decisions depend on the degree of risk aversion. For risk-neutral producers, foreign investment decisions do not depend on volatility in their framework. However, for risk-averse producers seeking to diversify risk, the share (though not necessarily the level) of foreign investment increases as exchange rate variability rises.
11. In general, the theory of investment assumes lags in the adjustment to the desired capital stock; we abstract from these considerations here. In the empirical analysis we implicitly take account of possible investment lags by including lags of the explanatory variables.
12. South Africa is excluded, even though it is among the top 30 largest U.S. trading partners, because of the world trade embargo in effect for most of the sample period.
13. Quarterly data for some variables, notably real GDP, were interpolated for some countries from annual data as described in the appendix.
14. The sample periods indicated in Table 5.2 allow for seven lags for each country in the pooled estimation of equations (5.3a) and (5.3b).
15. Various (nominal and real) exchange rate risk measures have been employed in international trade analyses. These include the absolute difference between current spot rates and corresponding earlier forward rates (Hooper and Kohlhagen 1978; Maskus 1986; Cushman 1988), the absolute value of current and/or lagged changes in the exchange rate (Bailey, Tavlas, and Ulan 1986), moving-sample standard deviations of past exchange rate changes (Ahktar and Hilton 1984; Gotur 1985; Kenen and Rodrik 1986; Cushman 1983, 1986, 1988; Bailey, Tavlas, and Ulan 1987; Koray and Lastrapes 1989; Klein 1990; Lastrapes and Koray 1990; Chowdhury 1993), and deviations of exchange rate changes from trend or other estimated processes (Cushman 1988; Peree and Steinherr 1989; Asseery and Peel 1991). Others have employed conditional variance measures based on ARCH models (Arize 1995; Kroner and Lastrapes 1993; Caporale and Doroodian 1994).
16. This assumption can be motivated by a monetary approach model to the balance of payments. See, for example, Girton and Roper (1977), who construct an exchange rate pressure variable with an incipient component defined similarly to ours. Note also that our definition abstracts from any intervention by the United States against currency j. This is a reasonable characterization of U.S. exchange rate policy.

17. Our *XRFLEX* variable remains quite stable for almost all countries when constructed over various five-year subperiods within the overall sample range, indicating that the exchange rate regime for individual countries does not change much over the sample.
18. We do not allow individual time trends in these individual country regressions. In the pooled regressions the time trend variable is constrained implicitly to be identical across countries. The results with respect to our hypotheses are not affected if the trend term is omitted from the pooled regression.
19. As with most other empirical analyses of international trade flows, it is assumed that the real exchange rate and income are predetermined with respect to trade flows. Possible simultaneity bias with our OLS estimates should be less important for analyzing the effects of risk on trade flows than for estimating the magnitude of trade elasticities. At the end of Section 5.4 we check the sensitivity of our results to estimating elasticities from cointegrating relationships.
20. Because the variables in Z_j are time-invariant by definition, the product of Z_j and the demeaned variables P_j and Y_j are also demeaned.
21. Mexico, a recent member of the OECD, is excluded from the OECD sample.
22. This was implemented with RATS' ROBUSTERRORS option.
23. These plots are available upon request.
24. This scatter gives only a suggestive understanding of the relation between the export elasticities and the degree of export flexibility because it ignores possible correlations among these variables and other variables in the general export regression. Countries with wrong signs are omitted.
25. A line fitted to the points in Figure 5.2 is significantly positive at better than 1 percent.
26. Denmark is removed from both samples, because with a high export elasticity (in absolute terms) and a very low degree of exchange risk flexibility, it appeared to be an extreme outlier. Removing it from the samples improved the significance of the results, without affecting signs.
27. We do not show a scatter plot for import elasticities and *XRFLEX* analogous to Figure 5.2 because of the problems of interpreting the import results.
28. The procedure was implemented with RATS' CATS procedure, with the DRIFT option (implying a random walk trend in the data space), for a three-variable system consisting of the (logged) real exchange rate, importing country GDP, and real trade flow, as well as seasonal dummies. The income variable was assumed to be weakly exogenous. For each country, enough lags were included to reduce the significance of any first-order serial correlation in the system's residuals to less than 5 percent. The reported elasticities were taken from normalization of the cointegrating relation. Countries with wrong signs for either the relative price or income variable are omitted.
29. A line fitted to the points in Figure 5.3 is significant at 8 percent.

30. For a review of the OCA literature a classic reference is Tower and Willett (1976). An updated review can be found in Wihlborg and Willett (1991). The classic references are Mundell (1961), McKinnon (1963), and Kenen (1969). Bayoumi and Eichengreen (this volume) present empirical tests of the predictions of this theory.

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